

PHYTOTOXICOLOGY
SECTION INVESTIGATION
IN THE VICINITY OF
VARTA BATTERY LTD.,
ST. THOMAS, 1989

JULY 1991



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Phytotoxicology Section
Air Resources Branch
Ontario Ministry of the Environment
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Background

Varta Battery Ltd. began operation in St. Thomas in 1981. A pre-operational Phytotoxicology Section vegetation assessment survey was conducted in 1980. Vegetation surveys have been conducted every year except for 1981 and 1988 (1,2,3,4,5 and 6). Soil surveys were conducted in 1980, 1981 and 1982 (see Appendix A for a summary of survey activities).

The company is located on the northeast outskirts of St. Thomas in an industrial park that is largely undeveloped and is still being farmed. There are some residences in the immediate area. Varta Battery is primarily a source of lead emissions, with smaller amounts of antimony also being emitted. Lead and antimony have been detected in vegetation in the immediate vicinity of the plant. The concentration of both metals has been gradually increasing in an irregular manner since 1980. The concentrations of lead and antimony have exceeded the Phytotoxicology Section's Upper Limit of Normal, at sample stations close to the source, on a regular basis since 1982.

Because of the lack of suitable species of vegetation to sample in the immediate vicinity of the company, an annual moss bag survey was established in 1984 to better delineate the pattern of atmospheric deposition (7). These moss bag surveys have shown a pattern of accumulation of lead and antimony downwind from the company to a distance of approximately half a kilometer.

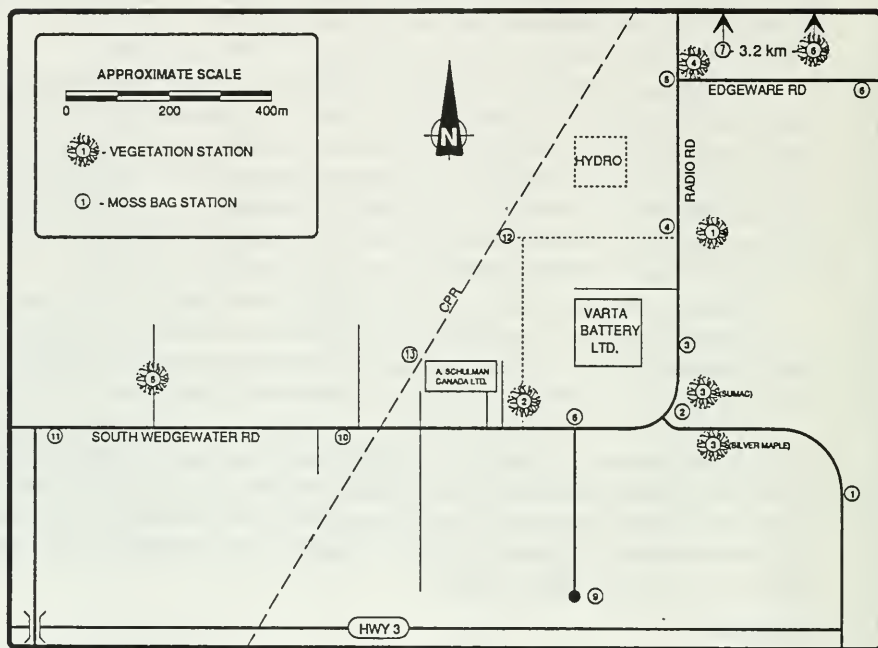
The concentrations of lead and antimony in vegetation and moss bags have been gradually increasing since the survey started (1). The highest levels were reached in 1986. In the late summer of 1986 the company had reported to the regional MOE office that a potential source of the emissions had been found and actions taken to correct the problem. The results of the 1987 survey showed a significant decrease in the lead levels in both vegetation and moss bags (1). The antimony levels did not show a corresponding decrease.

Methods

On May 30, 1989 Mr. R.D. Jones of the Phytotoxicology Section established a 13 station moss bag survey in the vicinity of Varta Battery Ltd., St. Thomas (see Figure 1). All of the moss bag stations were in the same locations as the previous moss bag surveys. The moss bags were changed monthly, on June 29, and July 28. The last moss bags were collected on August 29, at which time duplicate tree foliage samples were collected at six locations around Varta Battery (see Figure 1). The foliage was collected from the same trees as in the 1987 survey. The samples were collected using standard Phytotoxicology sampling techniques (8).

All samples were delivered to the Phytotoxicology Section sample processing laboratory in Toronto where they were dried and ground before being submitted to the Inorganic Trace Contaminants Section, Laboratory Services Branch for chemical analysis. All of the moss bags from the three monthly collections were submitted as one submission at the same time as the vegetation samples. The samples were analyzed for total lead, antimony, zinc, cadmium, copper, nickel, cobalt and aluminum.

Figure 1: Sketch Map Showing the Approximate Locations of the Vegetation and Moss Bag Sampling Stations in the Vicinity of Varta Battery Ltd., St. Thomas, 1989



Results

The results of the analysis of lead, antimony, cadmium and zinc in tree foliage are given in Table 1. The results for the analysis of copper, nickel, cobalt and aluminum in tree foliage are given in Table 2. All of the reported tree foliage results are the mean of duplicate samples.

The results of the analysis of lead, antimony, cadmium and zinc in moss bags are given in Table 3. The results for the analysis of copper, nickel, cobalt and aluminum in moss bags are given in Table 4.

All results are expressed as $\mu\text{g/g}$ on a dry weight basis. Phytotoxicology "Upper Limit of Normal" (ULN) Rural guidelines for each element are reported at the bottom of each table. Where results exceed the ULN guidelines the results are shown in bold italic type face.

Table 1: Results of Chemical Analysis for Lead, Antimony, Cadmium and Zinc in Tree Foliage Collected in the Vicinity of Varta Battery Ltd., St. Thomas, August 28, 1989

Station Number	Species	Lead μg/g	Antimony μg/g	Cadmium μg/g	Zinc μg/g
1	white oak	13	2.3	0.23	32
	silver maple	23	2.0	0.14	22
2	Manitoba maple	29	2.5	0.12	17
3	silver maple	6.4	2.0	0.19	32
	sumac	18	2.7	<0.1	16
4	silver maple	5.8	0.85	0.18	24
5	silver maple	4.3	0.45	0.28	12
6 ^a	white oak	1.2	<0.2	0.17	35
	silver maple	0.9	<0.2	<0.1	14
	sumac	1.4	<0.2	<0.1	19
Rural ULN		30	0.3	1.0	250

^a - control station.

Table 2: Results of Chemical Analysis for Copper, Nickel, Cobalt and Aluminum in Tree Foliage Collected in the Vicinity of Varta Battery Ltd., St. Thomas, August 28, 1989

Station Number	Species	Copper μg/g	Nickel μg/g	Cobalt μg/g	Aluminum μg/g
1	white oak	5.4	<0.5	0.2	29
	silver maple	5.5	0.9	0.4	53
2	Manitoba maple	4.5	<0.5	<0.2	66
3	silver maple	4.5	<0.5	<0.2	53
	sumac	4.5	0.8	<0.2	140
4	silver maple	4.8	0.7	<0.2	82
5	silver maple	3.8	0.9	0.3	76
6 ^a	white oak	9.0	0.5	<0.2	20
	silver maple	5.3	0.6	0.4	30
	sumac	5.1	<0.5	0.3	37
Rural ULN		20	5	2	500

^a - control station.

Table 3: Results of Chemical Analysis for Lead, Antimony, Cadmium and Zinc in Moss Bags in the Vicinity of Varta Battery Ltd., St. Thomas, June, July and August, 1989

Station Number	Chemical Analysis Results by Element and Month ($\mu\text{g/g}$ dry weight)											
	Lead			Antimony			Cadmium			Zinc		
	June	July	August	June	July	August	June	July	August	June	July	August
1	39	31	16	1.3	0.34	0.21	0.16	0.14	0.32	55	63	49
2	59	48	25	2.7	1.1	0.58	0.28	0.26	0.18	270	610	140
3	81	46	54	6.9	1.1	3.4	0.18	0.22	0.14	170	120	86
4	63	41	31	4.7	0.91	0.65	0.24	0.48	0.28	490	340	220
5	58	35	24	2.0	0.36	0.51	0.28	0.20	0.18	330	100	150
6	42	33	42	1.2	0.29	0.54	0.22	0.14	0.30	72	55	64
7 ^b	28	31	13	<2	0.25	<2	0.26	0.16	0.12	37	46	48
8	43	44	20	1.0	0.62	0.70	0.52	0.16	<10	50	68	45
9	38	44	16	0.46	0.36	0.22	0.34	0.22	0.26	150	59	100
10	35	37	16	1.1	0.39	0.32	0.26	0.22	0.26	44	57	60
11	30	33	26	0.31	0.25	0.29	0.12	0.18	0.32	69	89	57
12	42	38	21	1.6	0.53	0.35	0.66	0.26	0.48	480	100	78
13	43	38	19	1.1	0.33	0.40	4.6	0.36	0.66	63	61	61
Rural ULN	35			a			2			100		

a - Not enough data to determine upper limit of normal for antimony in moss bags in rural locations

^b - control station.

Table 4: Results of Chemical Analysis for Copper, Nickel, Cobalt and Aluminum in Moss Bags in the Vicinity of Varta Battery Ltd., St. Thomas, June, July and August, 1989

Station Number	Chemical Analysis Results by Element and Month ($\mu\text{g/g}$ dry weight)											
	Copper			Nickel			Cobalt			Aluminum		
	June	July	August	June	July	August	June	July	August	June	July	August
1	5.8	5.4	5.6	3.5	5.8	3.6	1.2	1.2	1.7	780	910	520
2	12.0	6.5	9.2	4.9	4.3	3.8	1.2	1.2	1.7	980	830	680
3	6.7	8.2	5.0	4.9	4.3	4.2	1.1	1.1	1.6	820	1000	530
4	80.0	20.0	30.0	11.0	11.0	5.0	1.1	1.4	1.7	850	940	730
5	13.0	5.9	8.6	4.6	4.0	4.2	1.1	1.1	1.6	730	1000	1000
6	5.8	5.9	5.7	4.6	4.6	4.5	0.9	1.2	1.1	740	1100	570
7 ^b	5.4	5.4	5.3	4.5	4.0	3.6	1.2	1.1	1.5	930	1100	520
8	6.4	5.5	4.4	6.0	4.5	3.8	1.1	1.2	1.1	960	950	810
9	6.8	6.5	6.4	6.9	4.1	5.7	1.3	1.1	1.6	920	940	620
10	6.5	5.1	5.3	4.4	4.0	3.4	1.0	1.1	1.9	840	800	860
11	37.0	33.0	12.0	4.2	7.4	4.5	1.1	1.2	1.1	1100	940	690
12	5.7	5.3	5.6	4.6	4.3	4.2	1.1	1.0	1.7	890	980	650
13	8.7	5.3	6.0	4.8	3.6	5.0	1.5	1.2	1.7	800	940	740
Rural ULN	8			6			a			1700		

a - Not enough data to determine upper limit of normal for cobalt in moss bags in rural locations

^b - control station.

Discussion

The levels of lead in tree foliage around the Varta Battery Ltd. plant in St. Thomas continued to show a significant decrease, as compared to the 1987 levels. The lead levels in tree foliage in 1989 were marginally lower than the 1987 results. Nineteen eighty nine is the first year since 1981, in which there were no exceedances of the Upper Limit of Normal for lead in vegetation. While the 1989 levels were the lowest since 1983, for the four closest stations they were still higher than the pre-operational levels, see Figure 2 below.

The lead levels in moss bags in 1989 were higher than the 1987 results. There were 20 exceedances of the ULN Rural guidelines for lead in moss bags in 1989 compared to eight in 1987. Most of the exceedances were in the month of June. The levels dropped throughout the summer, with the August 1989 results being similar to the August 1987 levels.

The 1989 antimony results for both vegetation and moss bags were not significantly different from previous years. There has been no drop in the levels of antimony at stations close to Varta Battery, as there has been for lead. For a comparison of the average lead and antimony levels in maple tree foliage at the stations 1, 2, 3 and 4, the closest stations to Varta Battery, from 1981 to 1989 see Figures 2 and 3 below. There were seven exceedances of the Rural ULN guidelines (all but the control station) for antimony in vegetation in 1989. This was similar to 1987. Although there are no ULN guidelines for antimony in moss bags, the pattern of rapidly decreasing levels with increased distance from Varta Battery implicates the company as an emission source of antimony.

Figure 2: Average Lead Levels in Maple Foliage for Stations 1, 2, 3 and 4

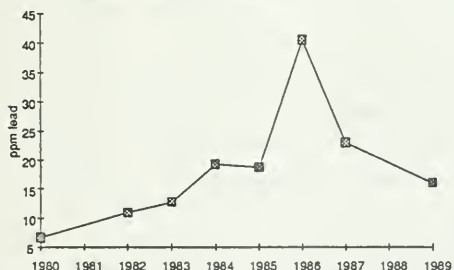
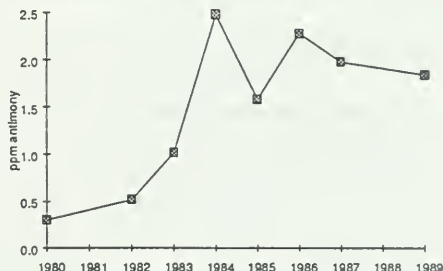


Figure 3: Average Antimony Levels in Maple Foliage for Stations 1, 2, 3 and 4



There was no discernable pattern of contamination of cadmium, zinc, copper, nickel, or cobalt in vegetation around the Varta Battery plant. There were slightly elevated levels of aluminum compared to the controls. The levels of cadmium, zinc, copper, nickel, cobalt, and aluminum were substantially lower than the Rural ULN guidelines for vegetation in 1989.

The slightly elevated levels of cadmium in moss bags reported previously near A. Schulman Canada Ltd. were also observed in 1989 (1). Slightly elevated levels were observed in moss bags at stations 12 and 13 in all three months. In June 1989, the Rural ULN for cadmium in moss bags was exceeded at station 13.

As in 1987, there were a number of exceedances of the Rural ULN guidelines for zinc in moss bags in 1989. The levels were higher in 1989 than in 1987 and 1986. Most of these exceedances were at stations 2,3,4 and 5, as was the case in 1987. There was a similar pattern for copper and to a lesser extent for nickel. Zinc and copper levels in moss bags exceeded the ULN guidelines by factors of 6 and 10 respectively. The levels were highest in June and lowest in August, similar to the lead levels in moss bags. While there was a trend around the Varta Battery plant, some of the exceedances occurred at stations 9 and 11, generally outside the zone of influence of Varta Battery.

Summary

Lead levels in vegetation in the vicinity of Varta Battery Ltd., St. Thomas continued to decline in 1989. There were no exceedances of the Rural Upper Limit of Normal guideline for lead in vegetation. The levels of lead in moss bags in 1989 were higher than the 1987 levels. The number of exceedances of the Rural ULN for lead in moss bags was similar to 1986. Most of the high lead levels in moss bags occurred in June, with the levels dropping to 1987 levels by August. While the actions taken by the company in 1986 to reduce lead emissions appear to have been successful, there still appears to be periods of elevated emissions. The level of antimony in both vegetation and moss bags in 1989 is not significantly different from previous years. The actions taken to reduce lead emissions have not been successful in reducing antimony emissions. Slightly elevated levels of cadmium in moss bags that were detected could be attributed to emissions from A. Schulman Canada Ltd. Elevated levels of zinc, copper and nickel in moss bags, but not vegetation, appear to be clustered around the Varta Battery plant suggesting that this operation may be an emission source of these elements.

Appendices

Appendix A Summary of Survey Activities

Table 4: Number of Stations Sampled for Soil, Vegetation and Moss Bags from 1980 to 1987.			
Year	Soil	Vegetation	Moss Bags
1980	6	6	
1981	6		
1982	6	6	
1983		6	
1984		6	12
1985		6	13
1986		6	13
1987	6	6	13
1989		6	13

Appendix B References

1. Ministry of Environment, Phytotoxicology Assessment Survey Investigation in the Vicinity of Varta Battery Ltd., St. Thomas, 1987, ARB-087-88-Phyto, ISBN 0-7729-4904-2
2. Ministry of Environment, Phytotoxicology Assessments of Vegetation and Soils for Heavy Metal Content in the Vicinity of Varta Battery Ltd., St. Thomas, 1980 to 1982., ARB-142-83-Phyt.
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8. Ontario Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch; Technical Support Sections - NE and NW Regions
9. Ontario Ministry of the Environment, 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section - Air Resources Branch ARB-138-88-Phyto. ISBN: 0-7729-5143-8

Appendix C Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and or snow from areas of Ontario not subject to the influence of point sources of emissions. "Urban" guidelines are based upon samples collected from centers of minimum 10,000 population. "Rural" guidelines are based upon samples collected from non-built-up areas. Samples were collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normal, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

Due to the large variability in element concentrations which may be present across Ontario, even in background data, control samples should always be collected. This is particularly important for soils, which may show large regional variations in element composition due to difference in parent material. Species of vegetation which naturally accumulate high levels of an element also may be encountered.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.

